

Distributional and regional economic impact of energy taxes in Belgium



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HIGHLIGHTS

- We study the impact of oil excises across regions and households in Belgium.
- Lower income groups gain if the revenue is used to raise welfare payments.
- If labour taxes are reduced, the reform is only slightly regressive.
- The differential impact across households is driven by factor price changes.
- Sector composition is a crucial determinant for impact variation across regions.

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ABSTRACT

We analyse the macroeconomic and distributional effects of increased oil excises in Belgium by combining a regional Computable General Equilibrium (CGE) model with a microsimulation framework that exploits the rich detail of household-level data. The link between the CGE model and the microlevel is top-down, feeding changes in commodity prices, factor returns and employment by sector into a microsimulation model. The results suggest that policymakers face an equity-efficiency trade-off driven by the choice of revenue recycling options. When the additional revenue is used to raise welfare transfers to households, the reform is beneficial for lower income groups, but output levels decrease in all regions. However, when the energy tax revenue is used to lower distortionary labour taxes, the tax shift is slightly regressive. In this case, national GDP is hardly affected but regional production levels diverge. The impact of the environmental tax reform on income distribution depends strongly on changes in factor prices and welfare payments, whereas sector composition is an important determinant for regional impact variation.

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1. Introduction

Policies to reduce carbon emission have become ubiquitous in both academic discussions and popular debates. Besides the differential impact of climate change across countries around the globe, one might wonder how energy and emission reduction policies affect inequality within countries. The potential regressivity of energy taxes may form an important obstacle for political acceptability of environmental fiscal reforms. In addition, regional economic impacts are likely to play a crucial role in the debate when politicians represent voters of different regions. This paper

studies the effects of increased oil excises on the distribution of household incomes and on regional economic activity in Belgium.

Environmental taxes can be argued to be regressive for various reasons. First of all, indirect taxation on the carbon or energy intensity of goods can raise the prices for certain commodities (e.g. oil fuel and petrol). Possibly, the consumption of these goods takes up a larger share of the budget for low-income households, who would therefore be affected disproportionately. Second, carbon taxes or tradable permit schemes can have a significant impact on factor incomes. The extent to which households depend on labour and capital income typically varies along the income distribution. The first argument depends on relative product prices and affects households on the uses side, whereas the second one is driven by relative factor prices and is referred to as an effect on the sources side (Musgrave, 1959). Other factors that may influence the incidence of environmental taxes are differences in endowments and sector composition across regions (Rausch et al., 2011), the

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distribution of benefits in environmental quality, and the extent to which all these effects capitalise into land prices (Fullerton, 2011).

Research reports usually find that environmental taxes are slightly regressive in developed countries (see Harrison (1995), Speck (1999) or Zhang and Baranzini (2004)). Studies that apply microsimulation techniques using household-level data tend to confirm these findings. For instance, Johnson et al. (1990) simulated expenditure responses to changes in consumption prices of energy, petrol and food. The results suggest that particularly price changes of energy products caused by e.g. value-added taxes or carbon taxes are likely to raise inequality. Decoster (1995) performed a similar analysis for the effects of a carbon tax in Belgium. His analysis identifies initial expenditure patterns as important drivers of the redistributive effects of indirect tax reforms. The heterogeneity in consumption responses to price changes seems to play a subordinate role for the distributional impact. A third illustration of a study into the regressive nature of green taxes using household-level data is provided by Metcalf (1999). He emphasises the potential of using the additional revenue to alleviate the burden of the tax reform for households at the lower end of the income distribution. For a more comprehensive review and discussion of the literature on environmental taxes, we refer to the chapter in the Mirrlees Review by Fullerton et al. (2010). In general, microsimulation is well-suited to address distributional implications of tax reforms because it allows incorporating the heterogeneity in characteristics and behaviour across individuals or households. However, analyses in partial equilibrium have common limitations, such as exogenous incidence of taxes and the absence of sectoral linkages that may be useful in assessing the economy-wide impact of policy reforms. For a more elaborate discussion on the use of microsimulation for inequality analyses, we refer to Bourguignon and Spadaro (2006).

The importance of initial tax distortions (Bovenberg and De Mooij, 1994) and revenue recycling options (Parry, 1995) in the analysis of environmental tax reforms calls for a general equilibrium framework in which consumption prices and wages are determined endogenously. Aggregate models in a general equilibrium setting, contrary to microsimulation, usually lack a sufficient degree of detail to adequately analyse welfare impacts for different groups of society. These studies therefore tend to focus on efficiency aspects and often present aggregate results in terms of economy-wide or sectoral production and pollution. One notable exception, however, is presented by Proost and Van Regemorter (1995). They applied a general equilibrium model that deviates from the assumption of one representative household by introducing four types of consumers, differing in employment status and sources of income (labour, capital and welfare payments). The dynamic simulations for an increase in excises on energy products compare two ways of recycling the additional tax revenue: raising the welfare payments or reducing employers' social security contributions. Whereas most studies that ignore equity aspects confirm the weak double dividend hypothesis¹ (see Goulder, 1995), Proost and Van Regemorter argue that this hypothesis need not hold when equity concerns are taken into account. The results under a flexible wage regime show that an inequality averse policymaker may prefer to raise the welfare benefits instead of lowering social security contributions. The reason is that welfare payments accrue more to the poor, whereas a reduction in labour taxes would mostly benefit the higher income groups.

A more recent strand of literature attempts to reconcile aggregate and disaggregate perspectives by linking Computable General Equilibrium (CGE) models with microsimulation models (MSM). The advantage of this approach is that it includes general

equilibrium feedbacks but nevertheless exploits the full detail captured by household-level data. Several variants of this approach can be distinguished². Chen and Ravallion (2004) illustrate a straightforward top-down link, transmitting CGE changes in prices and wages to household survey data to analyse the distributional impact of China's accession to the World Trade Organization. Their analysis assumes quantities are fixed, which comes down to unchanged labour and consumption behaviour of households. A second type of link strives for some consistency by reweighting the microdata in accordance with the CGE aggregates. Buddelmeyer et al. (2012) apply this approach to study the effects of climate change policies on income distribution in Australia. Employment and population changes are accounted for by adapting the sample weights of the households in the microdata. Since our work builds largely on methods presented by Buddelmeyer et al., this procedure for linking the CGE model with microsimulation will be discussed in more detail in Section 2.2. The authors analyse two scenarios (80 and 90% CO₂ reduction below the level in the year 2000 by 2050) of an Emissions Trading Scheme for Australia. The revenue generated by this programme is redistributed lump sum to the households. In aggregate, real net incomes seem to drop after the reform. For the lowest income quintile, however, the income loss is overcompensated by the lump sum transfer, such that overall income inequality as measured by the Gini index is reduced. Top-down links with explicit modelling of household behaviour at the microlevel can be found in Labandeira et al. (2009), who used a demand system on microdata, or in Robilliard et al. (2008), who employed a micro-module with endogenous occupational choices. Third, some studies develop an iterative procedure between aggregate and disaggregate models, referred to as a top-down/bottom-up method, which may be useful when the reform under study causes important microlevel changes that have effects on a macroscale (Savard, 2003). Finally, for a fully integrated CGE model based on household-level data we refer to the ambitious work of Rausch et al. (2011), who applied algorithms developed by Rutherford and Tarr (2008). Over 15,000 households are incorporated as individual agents in a general equilibrium setting in order to analyse carbon taxes in the US. One of the conclusions claims that a progressive impact of carbon pricing on the sources side can offset regressivity on the uses side. Interestingly, the authors point out impact variation across racial and ethnic groups, reflecting underlying differences in income and expenditure patterns.

This paper uses a top-down link between a regional computable general equilibrium model and a non-behavioural microsimulation framework. We analyse the distributional effects of an increase in excises on mineral oil in Belgium, taking into account employment, consumption price and income changes. In addition to describing the results in terms of household's characteristics, we break down the impact of the energy tax reform in employment, income and price effects. The next section discusses the methodology. First, we briefly describe the most important features of the CGE model. Next, we provide details on how we build the bridge between the CGE model and microsimulation. Results are presented in Section 3. The final section concludes.

2. Methods

2.1. CGE model

In this section we set out the most important features of the regional CGE model we have developed for this exercise. It is

¹ The 'weak double dividend' hypothesis states that recycling the additional revenue of increased environmental taxes by lowering pre-existing distortionary (e.g. labour) taxes is less costly than redistributing the extra tax income as lump sum transfers.

² An overview (of applications in international trade literature) is given by Hertel and Reimer (2005).

Table 1
Share in output by region and sector (IO table, 2005).

Industry branches	CPA aggregation	Belgium	Brussels	Flanders	Wallonia
1. Agriculture	01, 02, 05	1.53	0.64	1.72	1.74
2. Coal	10	0.07	0.09	0.04	0.11
3. Crude oil and refined oil products	23	3.26	6.90	2.68	1.97
4. Natural gas	11	0.43	0.24	0.62	0.02
5. Electric power	12, 40	1.88	2.97	1.51	2.06
6. Ferrous and non-ferrous ore and metals	13, 27, 28	4.69	1.28	4.90	6.87
7. Chemical products	24	7.51	4.08	8.11	8.60
8. Other energy intensive industries	14, 21, 26	3.15	1.54	2.95	5.03
9. Electrical goods	29, 30, 31, 32, 33	6.23	3.82	6.99	6.01
10. Transport equipment	34, 35	5.91	4.65	7.48	2.40
11. Other equipment goods	20, 22, 25, 36, 37	4.38	2.76	5.03	3.80
12. Consumer goods industries	15, 16, 17, 18, 19	7.42	4.37	8.37	7.17
13. Building and construction	45	5.52	4.14	5.77	5.91
14. Land transport	60	1.94	1.63	1.94	2.20
15. Other transport	61, 62	0.87	0.68	1.08	0.41
16. Credit and insurance	65, 66, 67	4.70	11.12	3.20	3.79
17. Other market services	50, 51, 52, 55, 63, 64, 70, 71, 72, 73, 74	29.45	36.52	28.06	27.68
18. Non-market services	41, 75, 80, 85, 90, 91, 92, 93, 95	11.05	12.58	9.52	14.24

largely based on the GEM-E3 model. For a full description, we refer to the model manual³. Here, we use a version of the model that covers Belgium and the rest of the world. We extend this framework by introducing the three regions in Belgium in a bottom-up fashion. For each of the three regions in Belgium, we model a representative household and 18 industry sectors. This way we take into account important differences in sectoral composition between the regions (see Table 1). One federal and three regional governments are included, as well as trade with the rest of the world.

Households maximise a Stone–Geary utility function by choosing the desired amounts of leisure and consumption goods, taking current prices (myopic) as given. The leisure choice determines the amount of labour supplied by the households. Expenditure on commodities is further allocated between non-durables (11 categories) and a stock of durable goods ('Heating' and 'Transport equipment'). The use of a durable involves the consumption of fuels, a non-durable. Excises are levied on this linked consumption. The modelling approach ensures that fuel prices affect the decision to acquire the durable (e.g. how many cars will be bought) and the use of the durable (e.g. the kilometres driven with the car). The diagram in Fig. A.1 in Appendix A visualises the structure of the household side. Note that this modelling approach abstracts from differences in skill levels between households and assumes all unemployment is voluntary.

Firms maximise profits subject to a Constant Elasticity of Substitution (CES) production technology with constant returns to scale. A nested structure, shown in Fig. A.2 in Appendix A, allows for more complex substitution patterns. On the first level, firms can substitute a stock of capital against a bundle of labour, energy and materials. The model is recursive dynamic through accumulation of capital over time. Within one period, the stock of capital is fixed, but each industry branch makes an investment decision (based on exogenous growth expectations and current prices) in order to obtain the desired capital stock in the next period. As a result, high capital prices in one period may lead to more investment. This in turn will expand the capital supply in the next period, thereby lowering capital prices. The investment demand is converted (using an investment matrix) into a demand for the outputs of the different sectors. Energy inputs in the

production process are subdivided into electricity, oil, gas and coal. On the firm side, excises on oil are levied on the volume of oil inputs in the production process. Table 1 shows the sector composition in the three regions in Belgium. The relatively high output share of energy intensive firms in Wallonia and the relative importance of service sectors in Brussels highlight the interregional differences in industry structure in Belgium.

Governments' behaviour is exogenous. Several government instruments are included, such as direct, indirect and energy taxes, welfare payments, subsidies and import duties. Federal and regional government budgets are interlinked via the Special Finance Act that organises the sharing of revenues of federal taxes (personal income taxes and VAT). The main distribution mechanisms are based on regional populations, the amount of personal income tax revenue collected in a region and a solidarity component that allocates funds to regions where personal income tax revenue per capita is lower than the national average. International trade is modelled according to the standard Armington (1969) assumption, which states that domestically produced goods and imports are imperfect substitutes. Exports are based on exogenous world demand, following the same reasoning. For Belgium, the assumption of a small open economy seems obvious, so we take world prices as exogenous and uninfluenced by the import demand. Interregional trade is not explicitly modelled.

Labour, goods and capital markets are simultaneously in equilibrium. First, labour supply matches labour demand in a countrywide, perfectly competitive labour market. This implicitly assumes perfect labour mobility (costless commuting). As a result, there is one wage that clears the labour market at a national level, where labour supply and demand are obtained by adding up the labour supply and demand in the three regions. Note that by assuming perfect competition, we abstract from union wage bargaining, involuntary unemployment and other labour market frictions. Our model set-up therefore only includes voluntary unemployment, driven by the household's choice of leisure over consumption for a given wage rate. Second, household, government, investment and export demand for each consumption category is transformed (by means of a consumption matrix) into demands for the outputs of each industry branch. The commodity market is in equilibrium at the country level, such that consumption prices are the same across the country (aside from small differences in regional taxation). We neglect cross-border shopping. Third, within each period, the capital stock is fixed per region and per industry sector. Capital supply therefore comes down to the existing stock of capital in one period. The capital market

³ More extensive model documentation (Capros et al., 2013) and related publications can be found on www.GEM-E3.net. For a recent application of the world GEM-E3 model, we refer to Ciscar et al. (2013).

equilibrium, where capital demand is determined by investment choices based on exogenous growth expectations and current prices (myopic), determines the price of capital. Part of the return on capital is paid out to households as capital owners (in Section 2.2 we will therefore assume that changes in self-employment income in the microdata follow the variation in the return on capital). Another part is retained within the firm, of which a fraction is paid out to the households as a dividend. The model is implicitly closed by imposing the zero profit condition, complete use of income, the equilibrium on the goods market and the government budget constraint. Household savings are modelled as a residual category, indicating the amount of income left after consumption expenditures.

The model's parameters are fixed in the calibration, such that the initial model equilibrium matches the observed situation in the base year (2005). The intuition of the calibration procedure is to use available data sources to set the values of all variables and parameters in an equation, except one. The remaining parameter is then obtained by rewriting the equation. Input-output tables, regional and national government accounts, household accounts, employment and wage data (made available to us by the Federal Planning Bureau) are combined in a consistent way to construct the social accounting matrices for the three regions. Input-output tables determine intermediate consumption linkages between firms. The model is therefore well-suited to address the economy-wide impact of policy reforms. Government and household accounts serve to pin down transfers between agents in the base year. Data on population, employment and wages are used to derive labour market parameters. Population projections are provided by Eurostat. Exogenous sector growth expectations, a factor that influences investment demand, are assumed to be around 2% for manufacturing industries, in line with OECD (2012) projections, and slightly higher (3%) for services sectors in the baseline. The consumption price elasticities vary across the different expenditure categories, but are identical across regions. Likewise, we assume that the substitution elasticities in production are the same in the three regions.

Finally, carbon emissions of firms are based on regional energy balance sheets, which contain information on the energy sources used in each sector, combined with default emission coefficients from IPCC (2006). Together with energy tax rates from the International Energy Agency (IEA), the energy balance sheets additionally serve to calibrate the initial level of energy taxes. Important exemptions for agriculture and water and air transport have been taken into account. In calculating the CO₂ emissions by households, we distinguish between the use of fuels for heating and transport purposes.

2.2. Link with microsimulation

The approach to combine the CGE model with microsimulation followed here is a top-down method, inspired by the work of Buddelmeyer et al. (2012). Our microsimulation framework is non-behavioural, which means that household behaviour is not modelled explicitly at the microlevel. Herault (2010) compared the link of a CGE model with two types of microsimulation: a behavioural module with endogenous occupational choices and a non-behavioural framework with a reweighting procedure to account for employment and population changes. The behavioural approach can take heterogeneity of preferences into account and may better capture employment changes both at the intensive and the extensive margin. The reweighting approach may introduce a small bias, since household characteristics or preferences that may affect the probability of labour market responses are not considered. Nevertheless, Herault (2010) suggested this approach seems to give a good approximation of distributional effects and is

simpler to apply. Also note that we do not use the output of the microsimulation as further input into the CGE model; the link is uni-directional. The CGE simulations result in changes in employment, consumption prices and factor returns, which are subsequently used as inputs for the household-level analysis.

The microdata we use draws from the European Union Statistics on Income and Living Conditions (EU-SILC), survey data that contains information on labour supply status (and industry sector, if the person is employed), education levels, age, region of residence, factor incomes, household composition and other characteristics of over 14,000 Belgian individuals. Expenditure data from the Household Budget Survey (HBS) is used as described below (in the fifth step). Decoster et al. (2013) described how the data from the EU-SILC and the HBS are combined.

The methodology can be summarised in five steps. The first step is concerned with consistency between aggregate and disaggregate data sources. Adding up the employment figures from the household survey does not reproduce the employment totals that can be found in regional accounts. We align the employment figures by changing the sample weights of the microdata, with as little deviation (measured by a chi-square function) from the original sample weights as possible, such that the labour supply in each region matches the aggregate numbers from the CGE model (L_i in region i). In addition, we keep the total size of the population (N) constant. In doing so, we generate the baseline pre-reform dataset. The reweighting procedure follows the methods described in Cai et al. (2006). Minimising the deviation D (measured by a chi-square function) between household sample weights s_k and new weights $w_{0,k}$ (subscript 0 refers to the pre-reform situation, subscript k represents the households in the sample, $k=1, \dots, K$), subject to constraints for regional labour supply ($l_{k,i}$ is the labour supply of household k living in region i) and population size comes down to solving the following optimisation problem:

$$\begin{aligned} \text{Min} D &= \frac{1}{2} \sum_{k=1}^K \frac{(w_{0,k} - s_k)^2}{s_k} \\ \text{s.t. } L_i &= \sum_{k=1}^K w_{0,k} l_{k,i} \\ N &= \sum_{k=1}^K s_k = \sum_{k=1}^K w_{0,k} \end{aligned}$$

In a second step, we use the same reweighting method to translate employment changes, induced by the policy reform, to the microlevel. Since both the aggregate and the household data contain information on industry sector, variations in employment can be taken into account by industry sector (again with the additional constraint on the population size). After matching both data sources, seven industry sectors remain, as shown in Table B.1 in Appendix B. This is a simple way to achieve consistency between aggregate and household level employment changes. The reweighting in this step thus minimises the distance between the weights obtained from the previous step ($w_{0,k}$) and a new set of weights ($w_{1,k}$). The constraints include employment totals for seven sectors and the total size of the population. A more advanced method to incorporate these variations at the microlevel would be to model behavioural reactions, for instance by means of a discrete choice labour supply model.

Furthermore, a policy reform can affect factor incomes (sources side). Fig. C.1 in Appendix C illustrates the extent to which different income groups rely on particular sources of income. For instance, the lowest income group receives the highest amount of unemployment benefits, whereas employment, self-employment and investment income is largest in the highest income group. The third step brings the real changes in welfare payments (e.g. pensions and unemployment benefits), wages, self-employment

income and investment income (e.g. dividends, as mentioned in Section 2.1), as predicted by the CGE, to the microdata by uprating households' income by source. Note that we transmit the real percentage changes. By using 'real' changes, there is no need to adapt the tax-benefit system to new price levels in the next step. The choice for percentage changes rather than absolute differences is driven by differences in absolute numbers between aggregate and microlevel data. Table 2 compares the components of household disposable income in both data sources in 2005 (EU-SILC 2006). The frequently encountered problem of under-reporting of capital income in household surveys is apparent from this comparison.

When households' incomes alter, some families may no longer be entitled to certain means-tested benefits, such as income support. Others start receiving benefits they were not eligible for in the pre-reform situation. In Belgium, the guaranteed minimum income is an example of a means-tested benefit scheme: only individuals with an income below a needs-adjusted threshold are eligible for this type of transfer. A tax-benefit calculator is designed to take these effects into account. The fourth step therefore uses EUROMOD to generate net disposable incomes. EUROMOD is an arithmetic microsimulation model that contains a detailed modelling of the legislative framework concerning taxes and benefits for the countries of the EU27, including Belgium. For more details on EUROMOD, see Sutherland (2001). Note that the uprating procedure in the previous step adjusts the total amount of welfare payments, whereas this step takes into account changes in eligibility.

Finally, varying levels of excise taxes will result in different consumption prices (uses side). The extent to which a household is affected by these price changes depends on expenditure patterns. Table 3 shows the initial expenditure patterns for the 13 consumption categories (along with the COICOP code aggregation) by

household income groups. The budget shares illustrate that food (category 1), housing (3) and heating fuels (4) clearly take up a larger share of the budget for lower income deciles. In addition, a comparison of budget shares in aggregate data and microdata shows roughly the same expenditure pattern (in the last two columns of Table 3). The final step aims at incorporating the impact variation on the 'uses side' by constructing household-specific consumption price indices (CPI_k). Based on expenditures from the HBS and price changes derived from the CGE simulations, we compute this index for household k as

$$CPI_k = \frac{\sum_c (p_{1,c}/p_{0,c}) e_{c,k}}{\sum_c e_{c,k}},$$

where $p_{0,c}$ and $p_{1,c}$ are the prices of consumption category c ($c = 1, \dots, 13$) before and after the reform respectively and $e_{c,k}$ is the expenditure by household k on commodity c . This household-specific price index, used to deflate incomes, will be higher for households who spend a large share of their budget on goods that experience a strong price increase. We do not include second order welfare effects caused by changes in consumption. A demand system could be estimated to model consumption behaviour. We refer to Labandeira et al. (2009) for an application on energy taxes. This approach is not followed here, as the results of Decoster (1995) suggest that the distributional impact of an environmental tax reform does not crucially depend on changes in consumption behaviour.

3. Results and discussion

This section first describes the two budget neutral policy reforms we analyse. Next, we discuss the impact on aggregate economic indicators and carbon emissions for the three regions in Belgium (Brussels, Flanders and Wallonia). Before going into the distributional implications (Section 3.4), we shed light on the sensitivity of the results. In Section 3.5, we decompose the results to distinguish the effects on the sources (income) and uses (expenditure) side. The sixth and final subsection studies characteristics of winners and losers.

3.1. Scenario description

We study two scenarios that double the federal excises on mineral oil. In terms of tax revenue, the excises on mineral oil are the most important environmental tax in Belgium. Generating slightly over 3.7 billion € in 2005 (around 1.2% of GDP), this tax represents more than half of all environmental taxes (Eurostat, 2005).

Table 2
Comparison of household income in aggregate data (CGE) and microdata (MSM).

Household income (Million €, 2005)			
	CGE	MSM	Difference (%)
Employment income	116,805	131,819	– 11.39
Self-employment income	30,496	19,534	56.12
Capital income (dividends etc.)	25,731	5209	393.96
Benefits received	56,041	51,524	8.77
Income taxes	40,863	40,682	0.44
Social contributions	19,290	20,558	– 6.17
Disposable income	168,920	146,845	15.03

Table 3
Expenditure shares by consumption categories and income deciles.

Expenditure categories	COICOP aggregation	Income deciles											Microdata average	CGE
		Low inc.										High inc.		
		1	2	3	4	5	6	7	8	9	10			
1. Food, beverages and tobacco	1	22.7	22.3	21.9	21.2	20.6	19.4	19.2	18.8	18	16.9	20		17.5
2. Clothing and footwear	2	3.5	3.9	4.2	4.4	4.9	5.3	5.6	5.8	6.1	5.9	5		5.6
3. Housing and water expenses	3111, 3113, 3114, 3261	18.5	15.3	13.6	12.4	11.4	9.7	9.2	8.2	7.5	6.5	11		16.6
4. Fuels and power	32 (without 3261)	8.2	7.9	7.7	7.3	6.8	6.3	6.1	5.8	5.4	5.2	6.6		4.3
5. Housing furniture and operation	4 (without 4311)	4.2	4.5	4.9	5	5.2	5.4	5.8	6	6.4	7	5.5		5.3
6. Heating and cooking appliances	4311	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.2		0.7
7. Medical care and health expenses	5	6.2	6.5	7	6.4	6	5.5	5.4	5.2	5	4.9	5.8		4.6
8. Transport equipment	61, 62 (without 6221)	4.7	5.2	5.1	6.1	6.7	8.8	8	8.7	9.1	10.4	7.4		7.9
9. Operation of transport equipment	6221	3.4	3.6	3.7	4	4.2	4.3	4.4	4.3	4.2	3.7	4		6.8
10. Purchased transport	63	0.8	0.6	0.5	0.6	0.6	0.5	0.5	0.6	0.5	0.6	0.6		1.2
11. Telecommunication services	64	3.9	3.9	3.8	3.8	3.9	3.8	3.7	3.7	3.5	3.2	3.7		2.1
12. Recreation, entertainment, etc.	7	13.4	15.2	15.8	17.1	17.9	18.5	19.3	20	20.7	21.4	18.1		14.1
13. Other services	8	10.5	11.1	11.7	11.6	11.8	12.1	12.6	12.8	13.4	14	12.2		13.1

Table 4
Aggregate results.

Difference (%) with reference (2050)	Transfer Scenario				Labour Tax Scenario			
	Brussels	Flanders	Wallonia	Belgium	Brussels	Flanders	Wallonia	Belgium
GDP	−0.14	−0.31	−0.85	−0.40	0.59	0.05	−0.51	0.03
Employment	1.93	−0.29	−1.99	−0.31	3.38	0.30	−1.36	0.46
Household cons.	0.34	0.22	0.20	0.22	2.40	0.22	0.00	0.31
Investment	0.11	−0.18	−0.78	−0.26	0.45	−0.01	−0.59	−0.05
CO ₂ emissions	−1.13	−2.55	−3.58	−2.63	−0.25	−2.61	−3.77	−2.59
Price index				1.03				0.69
Real wage				−0.34				1.17
Exports				−0.73				−0.22
Imports				−0.35				−0.14

Almost 45% is paid by households; the remaining revenue is collected from firms. Note that important exemptions hold for agriculture, air and water transport sectors. How the additional tax revenue of the reform is recycled can have important macroeconomic and distributional consequences. The choice of revenue recycling option distinguishes the two scenarios.

- In the ‘Transfer Scenario’, the additional revenue is used to increase the welfare payments by around 5%. These payments include pensions, unemployment benefits, child allowances, health benefits and various smaller transfers (family, education, housing, social assistance, and disability).
- In the ‘Labour Tax Scenario’, employers’ social security contributions are reduced by approximately 2 percentage points (from 26% to 24%). Note that taxes on labour in Belgium are among the highest in Europe, whereas the environmental taxes (including energy, transport and environmental and resource taxes) are relatively low compared to other EU countries (Eurostat, 2005). As argued by [Bovenberg and De Mooij \(1994\)](#), the initial tax distortions can be an important factor driving the results.

Note that both scenarios are budget neutral for the federal government. For clarification, we state the relation between the wage W , the labour cost faced by firms p_L and the wage received by the worker I_L as

$$p_L = \frac{W}{1 - \tau_{SS,F}}$$

$$I_L = (1 - \tau_{SS,H})(1 - \tau_{DT})W,$$

where $\tau_{SS,F}$ and $\tau_{SS,H}$ are the social security contributions on the firm and household side respectively. Direct taxes are represented by τ_{DT} .

3.2. Aggregate results

The energy tax increase we study is substantial, affects both producer and consumer side and can be expected to have a significant economy-wide impact. The macro-level impact predicted by the CGE model is displayed in [Table 4](#). We present the results as percentage differences from the baseline in the year 2050 only, as the results for other years yield the same conclusions.

In the Transfer Scenario, the tax increase raises production costs and influences the country's Gross Domestic Product (GDP, in volume) negatively. Although production seems to decrease in all three regions, Wallonia appears to be affected more strongly, whereas Brussels experiences only a small drop in output. The reason is the importance of energy-intensive industries in Wallonia, which are particularly affected by an increase in oil

excises. Brussels, on the contrary, mainly hosts headquarters and financial services. The regional variation becomes more apparent when looking at the evolution of employment. The decrease in employment in Flanders and Wallonia causes a downward pressure on the real wage, as shown in the lower part of [Table 4](#). Together with an increase in costs for oil as an input in production, this lowers the relative cost of labour, which leads to an increase in employment in Brussels. These results highlight the implications of a shared labour market, where firms from different regions hire workers from a common pool of labour. As such, the labour market is an important mechanism for interregional interactions. Via changes in wages, the impact of a policy reform in one region can spill over into one of the neighbouring regions. Despite the reduction in real wage, household consumption rises, driven by the strong increase in welfare payments. The reduction in investment is lower than the overall output reduction, indicating a shift towards capital (for Brussels investment even increases). In terms of environmental impact, the results suggest that carbon emissions decrease in all regions, most significantly in Wallonia, where CO₂ emissions are 3.58% lower than in the baseline. The emission reduction is induced by both a reduction in output, overall and of energy intensive industries, and a shift in the input structure in production⁴. As a result of higher input costs, the overall price level rises, causing a negative impact on competitiveness: exports decrease by 0.73%. Imports drop less than production, which indicates a substitution away from domestically produced goods. In addition to a common labour market, interregional trade could be a second channel for interregional interactions. Due to data limitations, however, our model set-up does not accommodate bilateral trade flows between the regions. The channel of interregional trade could further exacerbate the regional impact variation, as (intermediate and final) consumption may shift towards goods produced in other parts of the country, depending on the changes in competitiveness of the industries in Wallonia relative to those in the other regions. However, if firms in Wallonia import a substantial share of intermediate goods from the neighbouring regions, the drop in GDP in this region may spill over to the other regions via a reduction in import demand, affecting exports of Brussels and Flanders negatively.

In the case where the additional tax revenue is used to reduce labour taxes (social security contributions), a different picture appears. The right half of [Table 4](#) shows that replacing labour for energy taxes results in a small increase the country's GDP, although production in Wallonia also decreases in this scenario. Lowering labour taxes leads to a small rise in employment, despite

⁴ Note that the employment increase in Brussels may intensify commuting flows towards Belgium's capital. The additional congestion and pollution this may cause is not taken into account.

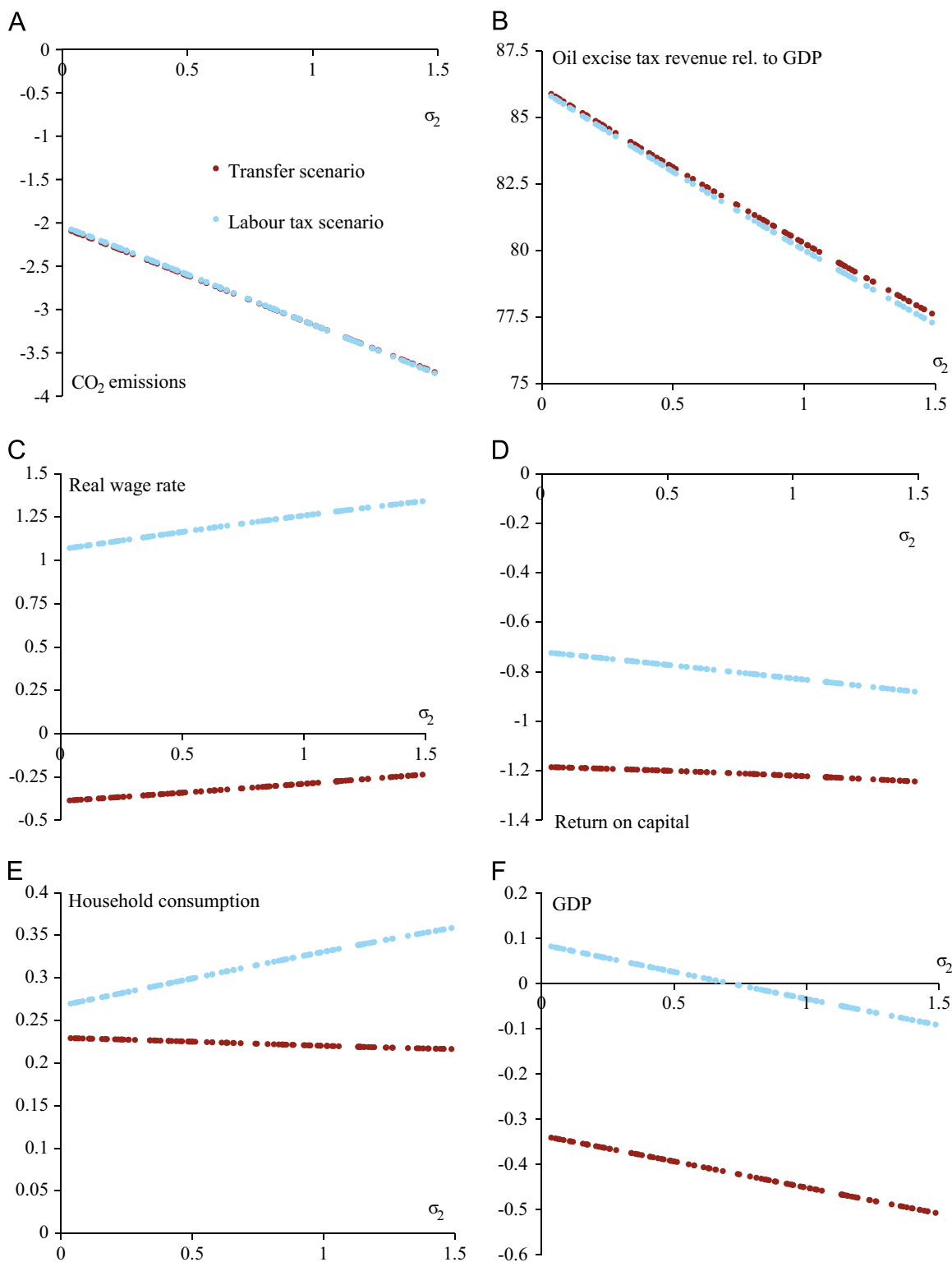


Fig. 1. Sensitivity of results (% change from baseline) w.r.t elasticity of substitution (σ_2) in the labour-energy-materials nest of production in oil-intensive sectors (6, 7, 8, 12 and 14).

the job loss in Wallonia, and an increase in real wages of 1.17%. This consequently raises disposable incomes and household consumption. A reduction in carbon intensity brings about a country-wide reduction in carbon emissions of 2.59%. Note that lowering pre-existing distortionary (labour) taxes seems to be less of an economic burden than recycling the revenue by means of a

transfer to households, thereby confirming weak double dividend claims. Furthermore, the results indicate the potential for a strong double dividend, a scenario in which both economic (in our case, an increase in GDP and consumption) and ecological gains (a reduction in CO₂ emissions) can be obtained from an environmental tax reform. Note that the initial level of labour taxes in

Belgium is among the highest in Europe, whereas the revenue from environmental taxes, relative to GDP, is below the EU average (Eurostat, 2005).

3.3. Sensitivity: the impact of factor substitution

Fullerton and Heutel (2007) set up a general equilibrium model to study the impact of an environmental tax on output prices, factor prices and pollution. Their framework includes a ‘clean’ and a ‘dirty’ sector, where the latter uses a polluting input in the production process. An analytical solution of the model illustrates how the burden of the tax on the polluting input falls on different input factors depending on substitution elasticities and factor intensities in production. The authors distinguish an ‘output effect’, indicating lower factor demand due to decreased output levels of the ‘dirty’ sector, and a ‘substitution effect’, describing the shift away from the polluting input towards other factors of production. Numerical simulations identify the elasticities of substitution between the polluting input and labour or capital in the production of the ‘dirty’ sector as a crucial parameter for the incidence of environmental taxes. Therefore, this section studies the sensitivity of the results presented in Section 3.2 with respect to the elasticity of substitution in the labour-energy-materials nest (σ_2 , see Fig. A.2) in the production of the oil-intensive industries⁵. The theoretical results of Fullerton and Heutel can serve as a guide to explain our results. However, the analysis performed here differs in a few important ways from their analytical model. First, we study a budget neutral reform, so revenue recycling will have an important feedback on the results. Second, changes in competitiveness affect industries via international trade. Third, by employing a CGE model, we include intersectoral linkages via intermediate consumption. Factor intensities vary across sectors as observed by input-output data.

Inspired by Canova (1994) and Cozzi (2012), we perform a Monte Carlo calibration in which we draw the value for σ_2 from a uniform distribution between 0.01 and 1.5 in each of the 100 model runs. Fig. 1 presents the outcome of this exercise by plotting the results of the two scenarios against different levels of the substitution elasticity σ_2 . For σ_2 equal to 0.5, the results match the numbers in Table 4. Panel A illustrates the sensitivity of the reduction in carbon emissions. As highlighted by Fullerton and Heutel (2007), the impact variation of pollution is substantial, ranging from around –2% to over –3.5% for high levels of the substitution elasticity. A stronger shift away from energy inputs towards labour and intermediate inputs (materials) results in lower CO₂ emissions. Consequently, the additional oil excise tax revenue falls for higher values of the substitution elasticity σ_2 (panel B). Although both scenarios simulate an increase of oil excises of 100%, the oil tax revenues only increase by 77–85% due to behavioural reactions: reduced consumption of oil-intensive goods, lower production levels of oil-intensive industries and the substitution of oil for other inputs in the production process.

When oil intensive firms can more readily replace energy with labour and materials in the production process, the relative demand for labour will rise. As a consequence, real wages increase. This is illustrated in panel C of Fig. 1 and indicates that the ‘substitution effect’ is becoming more important relative to the ‘output effect’. Capital becomes a relatively worse substitute for energy compared to labour and materials. Therefore, capital bears more of the tax burden when the value of σ_2 increases, as shown in panel D.

The sensitivity of household consumption (panel E) demonstrates the importance of the chosen revenue recycling mechanism. When firms are more flexible in replacing energy in the production process, the tax revenues that can be transferred to the households in the Transfer Scenario are lower. Although the negative impact on wages is mitigated by better substitution, the decreased transfer levels lead to a smaller increase in household consumption. When the additional revenue is recycled by lowering labour taxes (Labour Tax Scenario), however, the stronger increase in real wages leads to higher levels of household consumption (0.27–0.36% increase compared to the baseline levels). Panel F of Fig. 1 indicates that lower levels of household consumption lead to a greater decrease in GDP in the Transfer Scenario. In the Labour Tax Scenario, GDP levels drop when σ_2 rises, in spite of increasing domestic household consumption. The shift of oil-intensive firms towards labour and materials causes an upward pressure on the prices of these inputs. As a consequence, the competitive position of some export-oriented (labour-intensive) industry branches deteriorates. The resulting fall in exports drives the GDP levels down. Note that the sign of the change in GDP in the Labour Tax Scenario is affected by the value of the substitution elasticity: when σ_2 exceeds approximately 0.75, GDP is lower than in the baseline.

3.4. Distributional impact

Next, we turn to the impact of the reform on income distribution. Fig. 2 presents differences between monthly disposable income per income decile before and after the reform. Absolute differences $D_{A,d}$ (displayed in panel A of Fig. 2, € per month) and relative differences $D_{B,d}$ (panel B) per income decile d ($d = 1, \dots, 10$)

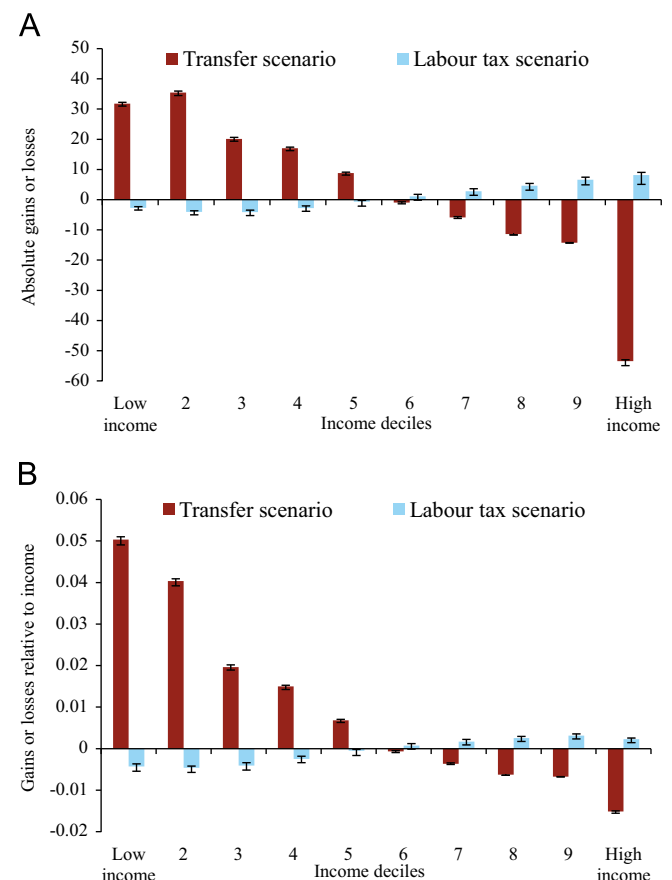


Fig. 2. Absolute (A) and relative (B) changes in monthly disposable household income (€).

⁵ More specifically, we vary σ_2 in the sectors with the highest share of oil excises paid relative to output: sectors 6, 7, 8, 12 and 14 (see Table 1).

are calculated as

$$D_{A,d} = \frac{\sum_{k \in d} w_{0,k} y_{0,k}}{\sum_{k \in d} w_{0,k}} - \frac{\sum_{k \in d} w_{1,k} y_{1,k}}{\sum_{k \in d} w_{1,k}}$$

$$D_{B,d} = D_{A,d} / \left(\frac{\sum_{k \in d} w_{0,k} y_{0,k}}{\sum_{k \in d} w_{0,k}} \right)$$

where $w_{0,k}$ and $w_{1,k}$ are the weights of household k before and after the reform, $y_{0,k}$ and $y_{1,k}$ their disposable incomes respectively. Because consumption needs do not increase proportionally with household size, we divide the disposable incomes by the square root of the number of household members (OECD equivalence scale). Also note that income deciles before and after the policy change may differ in composition, because income deciles after the reform are constructed on the basis of altered weights and pre-reform incomes.

Fig. 2 shows that the distributional effects vary strongly according to the way the additional revenue is recycled. Increased welfare payments (Transfer Scenario) seem to benefit mostly the lower income deciles. This is not surprising, since the share of pensioners and unemployed is higher in these income groups. However, higher excise levies impose a burden on the industry sectors. The increased production costs lead to higher consumption prices.

Furthermore, the transfer scenario entails reductions in real wages (−0.34%), capital (−1.20%) and self-employment income (−1.12%), which mostly harm higher income groups. The shift from labour to energy taxation (Labour Tax Scenario), on the other hand, appears to be slightly regressive. Reduced labour taxes lead to an increase of overall employment and the real wage rises. However, the lower income deciles hardly gain from the moderate real wage increase of 1.17% because labour incomes and employment rates in these income groups are lower. They are worse off because the overall price level rises as a consequence of higher production costs and more excises paid by consumers. The gains of households at the higher end of the income distribution are limited by a decrease in capital (−0.76%) and self-employment income (−0.64%).

Panel B of Fig. 2, displaying gains and losses relative to disposable income, leads to the same conclusion: redistributing the additional energy tax revenue through welfare transfers is beneficial for lower income households, while labour tax reductions may give rise to increasing inequality. The error bars in both panels of Fig. 2 match the upper and lower bounds of the results for the extreme values considered in the sensitivity analysis in Section 3.3 ($\sigma_2=0.01$ and $\sigma_2=1.5$). The conclusions of the distributional analysis do not appear to be very volatile with respect to variations in the substitution elasticity σ_2 . Remark that high values of σ_2 lead to larger falls in the

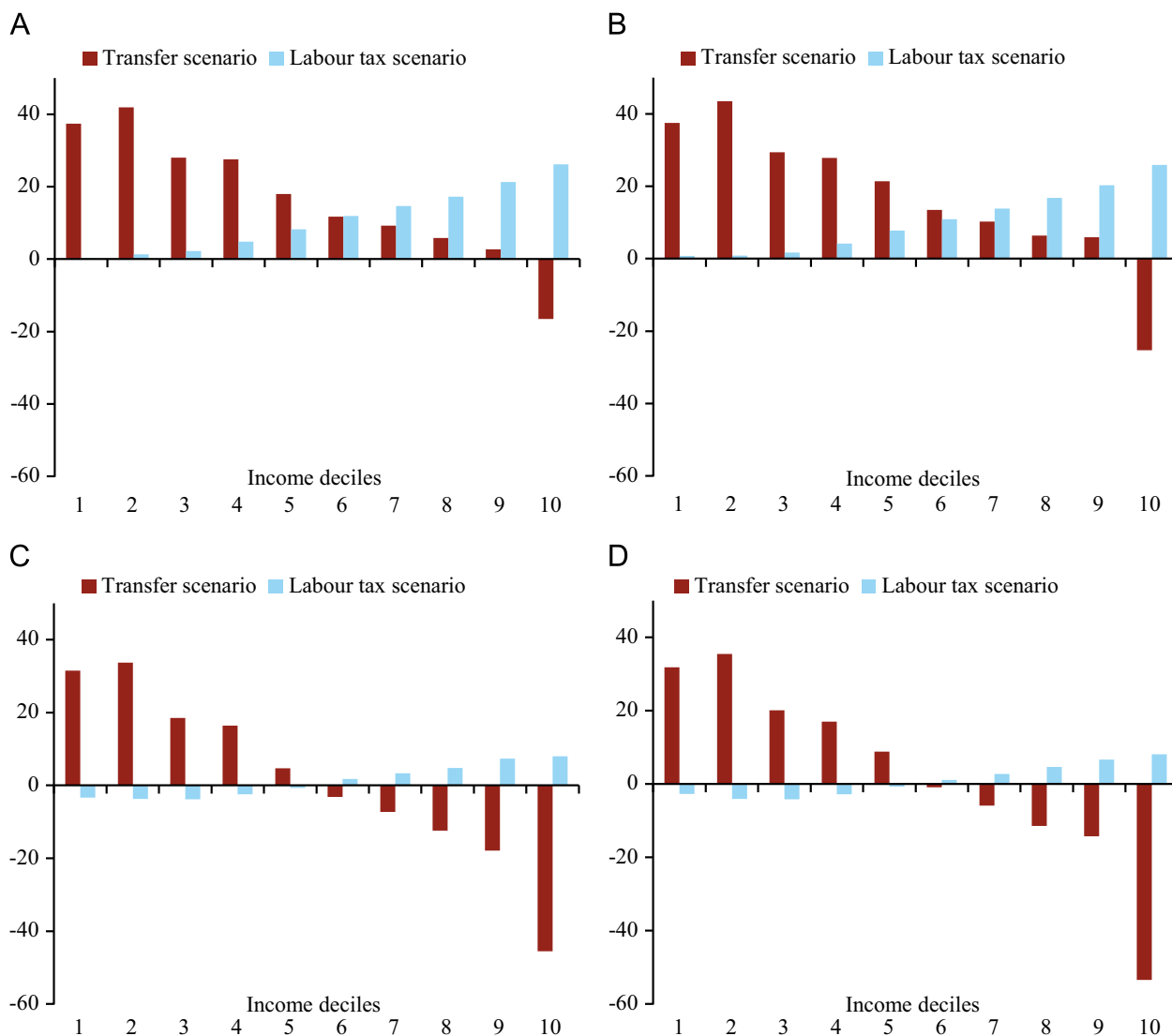


Fig. 3. Decomposition of the (absolute) effects on income distribution. (a) Before reweighting and price change, (b) After reweighting, before price change, (c) Before reweighting, after price change and (d) After reweighting and price change.

return on capital. This is illustrated by the downward sensitivity of income changes of the highest income group.

3.5. Decomposition

In this section, we zoom in on the distributional effects of employment, factor income and consumption price changes. Fig. 3 decomposes the overall impact by displaying intermediate results (panel D shows the final result, as in panel A of Fig. 2).

Panel A shows absolute differences in disposable income after taking into account factor income changes and variations in benefit entitlements (in EUROMOD). The sources side seems to be crucial in determining the impact variation across income deciles. More details on the initial distribution of factor incomes can be found in Fig. C.1 in Appendix C.

Panel B illustrates the impact of employment changes, included by changing sample weights. This figure largely shows the same structure as in panel A. Although the changes in weight differ by disposable income (as is shown in Fig. 4, with $w_{1,k} - w_{0,k}$ on the vertical axes), the relatively small changes in employment do not seem to change the conclusions that could be drawn from panel A. Possibly, an explicit modelling of labour supply reactions at the intensive and extensive margin, as is done in discrete labour supply models, is more suitable to address distributional concerns of employment changes.

We move from panels A–C in Fig. 3 by incorporating consumption price changes based on household specific expenditure patterns. The

increase in price level shifts the picture of panel A in Fig. 3 downwards. Consumption prices increase for two reasons. First, higher excises on the household side raise final consumption prices. Second, increased excise levies raise the production costs for firms directly (oil used in the production process) and via more expensive intermediate goods. Reducing labour taxes partially offsets the latter effect by lowering production costs. Therefore, the price increase in the Transfer Scenario is more substantial. This is illustrated by the slightly larger downward

Table 5
Price changes by consumption categories.

Expenditure categories	Price changes	
	Transfer Scenario	Labour Tax Scenario
1. Food, beverages and tobacco	0.3	0.1
2. Clothing and footwear	0.4	0.1
3. Housing and water expenses	0.3	0.0
4. Fuels and power	0.8	0.6
5. Housing furniture and operation	0.3	0.0
6. Heating and cooking appliances	0.2	0.0
7. Medical care and health expenses	0.5	–0.1
8. Transport equipment	0.2	0.0
9. Operation of transport equipment	14.3	14
10. Purchased transport	1.2	0.8
11. Telecommunication services	0.3	0.0
12. Recreation, entertainment, etc.	0.4	0.0
13. Other services	0.4	–0.1

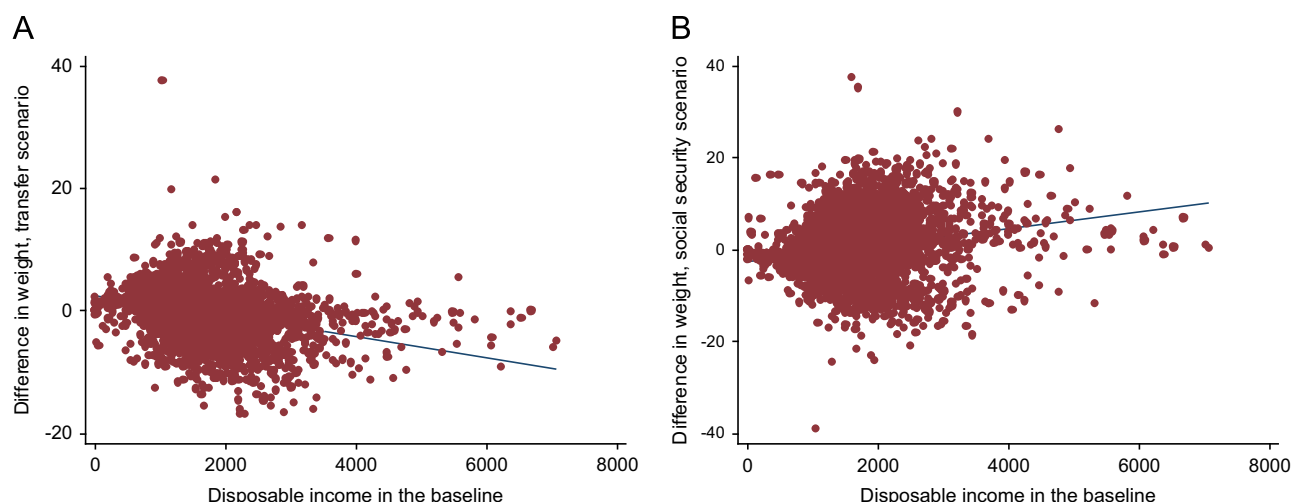


Fig. 4. Difference between new and old weights in the Transfer (A) and Labour Tax (B) Scenario.

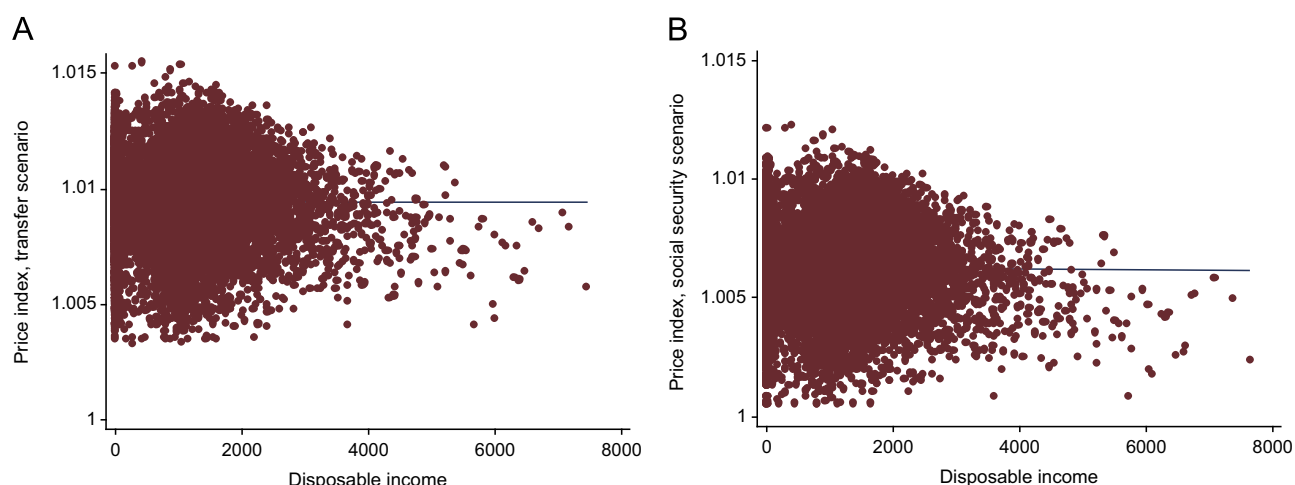


Fig. 5. Household specific price indices by disposable income.

Table 6
Impact by household characteristics.

Characteristics of winners and losers	Quintiles					
	Av.	20% losers	2	3	4	20% winners
Transfer Scenario						
Share employment income in disp. income (%)	74.81	137.28	128.21	88.42	15.56	4.68
Share transfers in disposable income (%)	42.05	2.23	3.67	20.80	82.90	100.50
Highest education level in household	3.52	4.47	3.96	3.41	2.78	2.95
Share 'private transport' expenditures (%)	3.98	4.31	4.67	4.14	3.42	3.34
Household size	2.43	3.37	2.73	2.16	1.80	2.08
Number of people aged over 60 per household	0.39	0.02	0.02	0.13	0.69	1.09
Number of people aged under 18 per household	0.29	0.51	0.40	0.26	0.14	0.10
Absolute gain or loss (–)	0.30	–75.57	–36.57	–1.66	41.40	73.97
Labour Tax Scenario						
Share employment income in disp. income (%)	74.81	6.95	8.83	67.57	136.37	154.29
Share transfers in disposable income (%)	42.05	70.54	88.39	41.80	6.58	2.94
Highest education level in household	3.52	3.55	2.65	3.13	3.81	4.43
Share 'private transport' expenditures (%)	3.98	3.95	3.53	3.77	4.70	3.93
Household size	2.43	2.43	1.79	2.18	2.57	3.17
Number of people aged over 60 per household	0.39	0.82	0.79	0.26	0.04	0.03
Number of people aged under 18 per household	0.29	0.24	0.15	0.27	0.35	0.42
Absolute gain or loss (–)	2.36	–17.01	–6.22	–0.84	9.56	26.33

shift in the case of revenue recycling via welfare payments. However, the contribution of the household specific price changes to the impact variation across deciles appears to play a minor role. A first explanation can be found in Fig. 5. This figure plots the household specific price indices (CPI_k) against disposable incomes. For the Transfer Scenario, the value of the price index ranges from 1.003 to 1.15. In the Labour Tax Scenario, price changes vary from nearly 0% (price index equal to 1) to 1.2% ($CPI_k = 1.012$). A clear increasing or decreasing trend is absent in both scenarios, indicating that the impact of the prices changes is not particularly concentrated in specific ranges of the income distribution.

A clearer picture can be drawn when we use the price changes by consumption category displayed in Table 5. The increase in excises on oil mainly raises prices of transport fuels (category 9). Price increases for heating fuels (category 4) and public transport (category 10) are rather limited. This can be explained by the importance of the excise component (paid by consumers) in transport fuels. The use of heating fuels is more diversified, as many households use heating systems based on electricity and natural gas. The price increases of other goods categories are minimal because the share of oil excises (paid by producers) in total production costs is limited. Since the burden of excises mostly falls on transport fuels and budget shares of this category are not decreasing by income decile (as shown in Table 3), the impact on inequality is ambiguous.

3.6. Winners and losers

To illustrate the richness of microdata, we can decompose the impact by household characteristics. CGE models with representative households usually lack the details to do this kind of analysis. A more refined view of the household groups that are affected by the policy reform may provide valuable information for policymakers, especially when the policy change is part of a larger reform package. An insightful way to map the effects by household characteristics is by ranking households according to how they are affected by the policy reform (from biggest loss to largest gain) and then grouping them in quintiles. Table 6 describes some characteristics of these quintiles. The households for which the burden is largest in the Transfer Scenario are highly dependent on employment income⁶ and receive low amounts

of welfare payments. Moreover, these households spend a larger than average share of their budget on transport fuels. Households benefiting from the reform tend to be smaller and contain on average more elderly (aged over 60) and less children. A potential explanation is that households with pensioners receive more welfare payments (pensions). The highest education level (ranging from 0 to 5) in households that gain seems to be lower than average. This may be explained by a positive correlation between education level and employment income. The second part of Table 6 presents the same information for the Labour Tax Scenario. Households that benefit from reduced labour taxes tend to rely heavily on employment income, have a higher education level and include less people with an age of 60 or higher.

4. Conclusions

We analyse aggregate and distributional effects of increased excise levies on oil in Belgium. Revenue is recycled either by raising welfare payments or by reducing employers' social security contributions (labour taxes). In terms of methodology, we follow a recent strand of the literature that attempts to link CGE models with a (non-behavioural) microsimulation framework. The main benefit of this approach is that it includes general equilibrium feedbacks and endogenous price changes, but nevertheless exploits the rich set of details of microlevel data. A number of conclusions can be drawn.

First, the results suggest the existence of a weak double dividend. On the country level, GDP drops when additional revenue is handed out to households as a transfer. When labour taxes are reduced, the country's GDP slightly increases (depending on parameter values), which indicates the potential for a strong double dividend. Second, we point out important regional impact differences. Due to the sector composition, GDP in the region that hosts more energy intensive industries (Wallonia) decreases in both scenarios. Since this region has lower per capita production levels to start with, both scenarios give rise to a regional divergence in economic activity. Third, using additional tax revenue to increase welfare benefits results in gains for lower income households. A reduction in wage and return to capital makes high income deciles worse off in this scenario. When the revenue is recycled through lower labour taxes, the environmental tax reform is slightly regressive. However, the key message to policymakers is that the regressive impact of higher oil excises can be

⁶ Note that these numbers involve pre-tax incomes, such that the share can exceed 100%.

offset by targeted revenue recycling. Fourth, the distributional effects seem to be driven by sources side effects (relative factor prices). Effects on the uses side (relative consumption prices) do not contribute much to the impact variation because the increase in oil excises mainly falls on transport fuels, which do not particularly take up a larger share of expenditures for lower income households.

The methodology applied in this paper can be refined in several ways. First, the CGE model could be extended to incorporate different skill levels of workers. A differential impact on wages for low-skilled versus high-skilled workers can be an additional determinant of the incidence of energy taxes. In addition, labour market imperfections (e.g. involuntary unemployment and imperfect labour mobility) and interregional trade could be included in the CGE model. Second, one could use a discrete choice labour supply model (e.g. taking into account heterogeneous opportunities for different individuals, as in [Aaberge and Colombino, 2013](#)) to derive household employment decisions. This way, a more realistic view could be given on who gains from job creation by modelling explicitly who is likely to fill in new positions. Third, and most fundamental, a fully integrated approach with a CGE model based on microdata could be adopted to combine the advantages of general equilibrium and micro-level modelling tools (see [Rutherford and Tarr, 2008](#)). Given the growing interest in the distributional consequences of policy reforms, future research efforts that align macro and micro perspectives in an

integrated manner will provide valuable information for political choices.

Disclaimer

The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

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Appendix A. Structure of consumption and production in CGE model

See [Figs. A1 and A2](#).

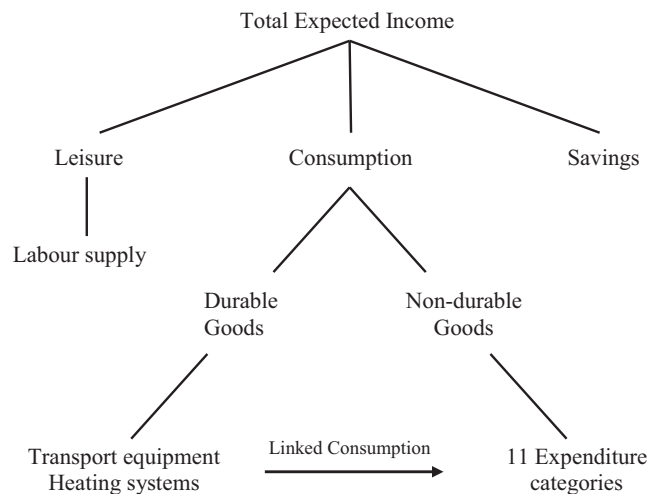


Fig. A.1. Consumption structure.

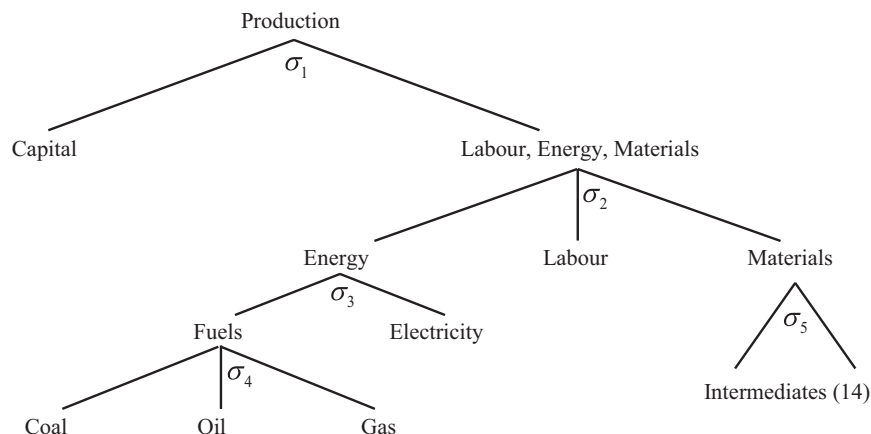


Fig. A.2. Nested CES production structure.

Appendix B. Matching production sectors

See [Table B1](#).

Table B.1

The combination of sectoral info from the CGE and microdata results in seven industry sectors.

Sectors after linking	Microsimulation	CGE
1 Agriculture and fishing	1 Agriculture and fishing	1 Agriculture
2 Mining, manufact. and utilities	2 Mining, manufact. and utilities	2 Coal
		3 Crude oil and refined oil products
		4 Natural gas
		5 Electric power
		6 Ferrous and non-fer. ore and metals
		7 Chemical products
		8 Other energy intensive ind.
		9 Electrical goods
		10 Transport equipment
		11 Other equipment goods
		12 Consumer goods industries
3 Construction	3 Construction	13 Building and construction
4 Other market services	4 Wholesale and retail	17 Other market services
	5 Hotels and restaurants	
	8 Real estate and business	
5 Transport and communication	6 Transport and communication	14 Land transport
		15 Other transport
6 Financial intermediation	7 Financial intermediation	16 Credit and insurance
7 Non-market services	9 Public administ. and defence	18 Non-market services
	10 Education	
	11 Health and social work	
	12 Other	

Appendix C. Income distribution by source

See [Fig. C1](#).

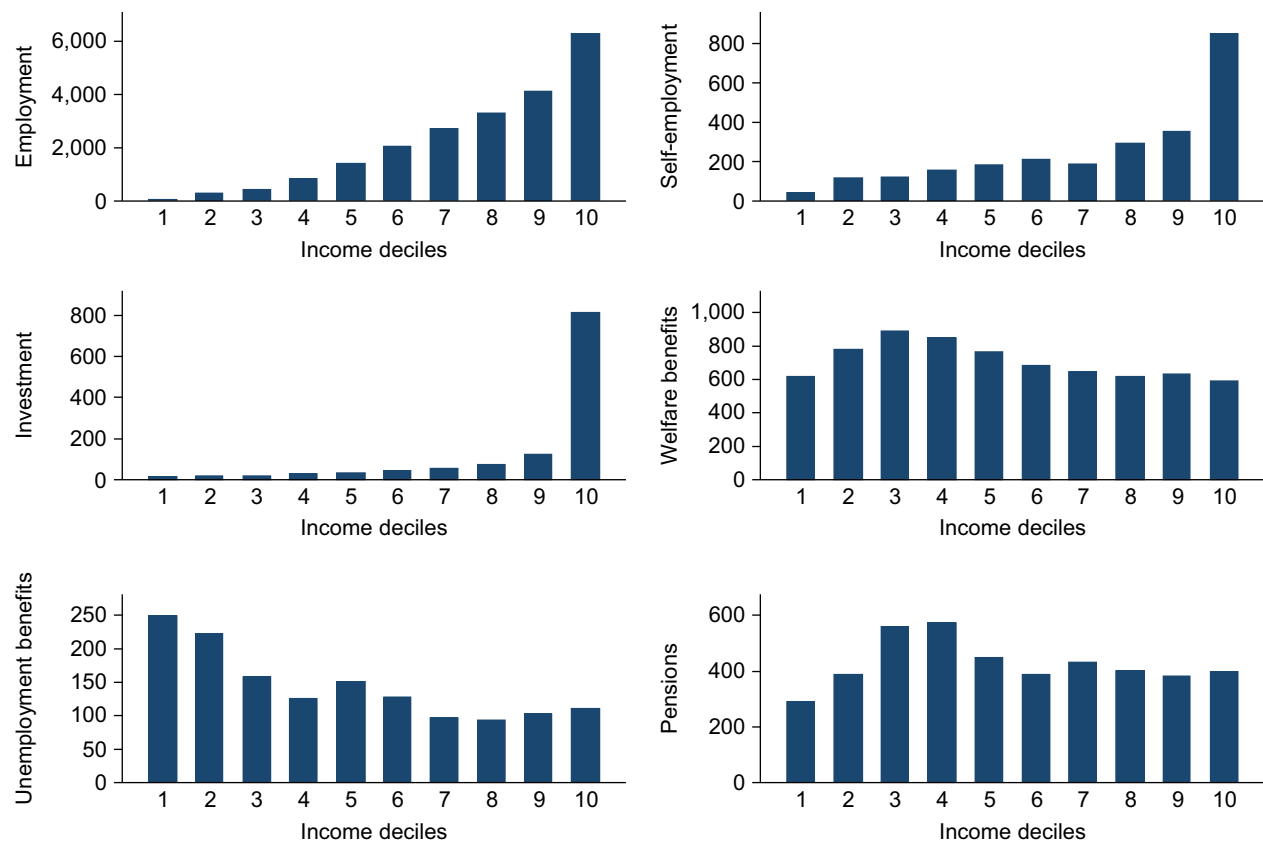


Fig. C.1. Distribution of income by source (€ per month, EU-SILC 2006).

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